Non-Linear Rheological Properties and Neutron Scattering Investigation on Dilute Ring-Linear Blends

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SQUEEZING OF DEFORMABLE DROPS THROUGH GRANULAR MATERIALS

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ABSTRACT

Flow of an emulsion of deformable drops through a randomly packed granular material is relevant to oil recovery and other applications. Of particular interest are the pressure-gradient/flow-rate relationships, the critical conditions when squeezing stops due to drop blockage in the pores by capillary forces, and the effects of drop breakup. For drops comparable in size with the particles, an effective-medium emulsion model is invalid. We perform instead rigorous multidrop-multiparticle simulations, with distinct velocities for the drop and continuous phases. The material skeleton is simulated as a "Random Loose Packing" of equisized solid spheres held in a periodic box in mechanical equilibrium, with highly frictional contact forces and the particle volume fraction of 0.5-0.55. For the flow, the multipole-accelerated boundary-integral (BI) algorithm [1] is vastly extended. Topological mesh changes on drop surfaces and a novel fragmentation algorithm are incorporated to simulate a cascade of multiple drop breakups (up to 50) observed at sufficiently large capillary numbers *Ca*; the results are time- and ensemble- averaged over many realizations of a granular material. With tight squeezing, severe computational difficulties are due to necessary high resolution (~ 10K boundary elements per each surface) and a large number (~100K) of time steps. Multipole acceleration, making the solutions feasible with up to 36 solids and 100 drops in a box, has an O(100) gain over the standard BI coding. The system size effects are explored. After a cascade of all breakups, the initially monodisperse system is shown to attain a statistically steady state; the phase velocities equilibrate much faster than the drop-size distribution does. Typically, the drops are compact at breakup, and the fragments are comparable in size.For matching viscosities, drop concentration of 40% in the available space, and drop-to-particle size ratio of 0.5, the phase permeabilities are studied vs. *Ca*. At large *Ca*, the drop-phase velocity is larger than the continuous-phase velocity, but the trend reverses as the drops become less deformable; the critical *Ca* for the drop-phase squeezing to occur is evaluated. The results are also obtained for a single drop travelling through random granular materials, loosely and closely packed.

[1] Zinchenko A.Z., Davis R.H. 2008 Algorithm for direct numerical simulation of emulsion flow through a granular material. J. Comput. Phys., **227**, 7841-7888.

NON-LINEAR RHEOLOGICAL PROPERTIES AND NEUTRON SCATTERING INVESTIGATION ON DILUTE RING-LINEAR BLENDS

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ABSTRACT

Linear and non-linear Rheology on dilute blends of polystyrene ring polymers in linear matrix is combined with Small Angle Neutron Scattering (SANS) investigations. In this way 2 different entanglement interactions become clear. After stretching the samples to different hencky strains up to 2 in a filament stretching rheometer, followed by quenching, strong anisotropic scattering patterns were obtained which were described by affinely deformed rings which function as giant, polymeric chemical crosslinks or sliplinks and more or less isotropic topological contributions from the entangling with interpenetrating linear chains. At the same time the non-linear rheological and mechanical data fit to a non-affine slip-tube model as for moderately crosslinked networks and to interchain pressure models or a modified non-linear Doi-Edwards description for the observed strain hardening during the extensional rheology. The entangled situation is thought to be responsible for the different terminal behaviour observed in ring polymers with traces of linear impurities. A comparison with a dilute blend of a linear chain of the same size as the ring polymer in the longer matrix is made.